Composition Effects on the Early-stage Oxidation Kinetics of (001) Cu-Au Alloys

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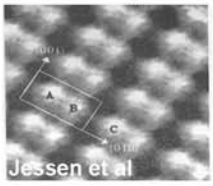
Motivation

A substantial gap exists between the information available from surface-science studies, *i.e.*, at low oxygen coverage, and that provided by bulk oxidation studies.

O_2 surface chemisorption → Early-Stage Oxidation → Later stages of oxidation



Surface reconstruction (001) Cu

?

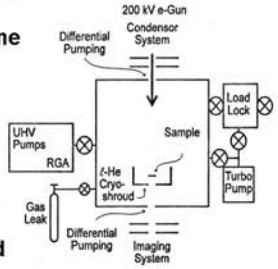
Missing

Bulk Copper Oxide

Experimental approach

In-situ environmental transmission electron microscope (MRL, UIUC)

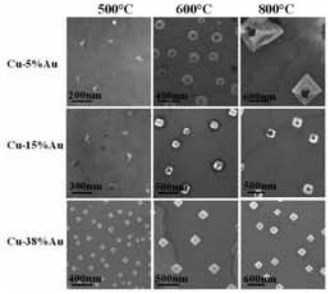
- Visualization of oxidation in real time
- Nanometer scale information
- Clean surface: down to 10^{-9} torr
- Information on buried interface
- Local reaction rate and the size and structural evolution of single oxide islands

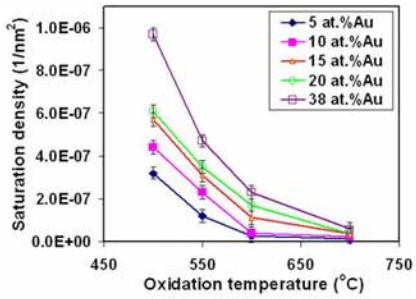


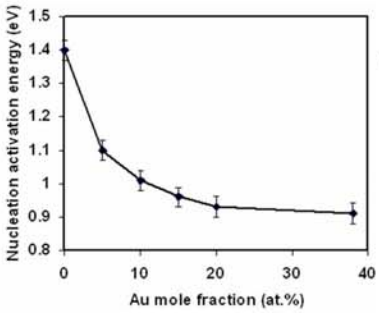
Accomplishments

Effect of Au on the nucleation of oxide islands

Dependence of number density of oxide islands and nucleation activation energy on alloy composition: $pO_2=5\times10^{-4}$ Torr

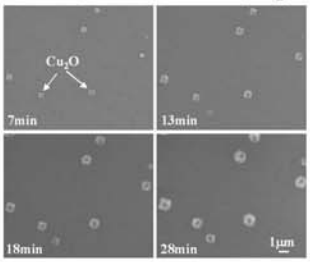


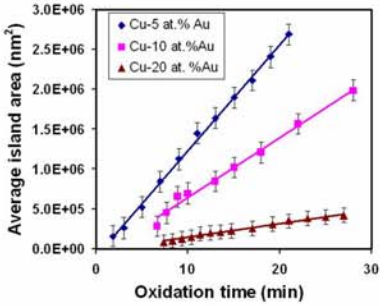


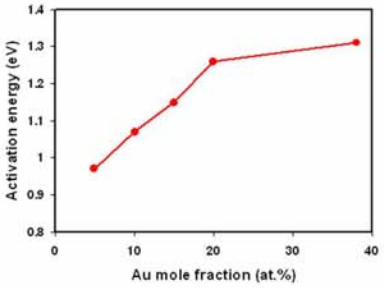


Effect of Au on the growth of oxide islands

Dependence of oxide island growth rate and apparent activation energy for oxide growth on alloy composition: $pO_2=5\times10^{-4}$ Torr







Observations:

- Au enhances nucleation of oxide islands during Cu-Au oxidation
- Au suppresses oxide island growth
- Alloy composition has an effect on the morphology of oxide island

Impacts:

- The morphology of the oxide film is strongly influenced by oxide nucleation and early-stage growth of oxide islands
- The passivation behavior of metals is strongly influenced by the microstructures of the oxide film that forms.
- The control of oxide formation in early-stage oxidation is critical in development of protective oxide layer

Future directions

In-situ TEM, SEM and X-ray scattering

Early-stage oxidation of alloys containing two and more oxidizable metals

- Temperature
- Oxygen pressure
- Alloy composition

Atomic-scale metal oxidation and corrosion:

- identify and characterize active sites
- reaction paths
- activation energy

G.-W. Zhou, J.A. Eastman, R.C. Birtcher, P.M. Baldo, J.E. Pearson, L. Wang, J.C. Yang, "Composition effect of on the early-stage oxidation kinetics of (100)Cu-Au alloys", Applied Physics Letters (submitted)

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This work was supported by the U.S. Department of Energy, Basic Energy Sciences, under contract W-31-109-ENG-38.

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